# The AGN PKS 2005−489 shows a peculiar hardening with extreme orphan X-ray band outbursts. It returns to identical flux levels during quiet states.

## The peculiar variable X-ray spectrum of the AGN PKS 2005−489

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**Introduction**

PKS 2005−489 is a well known southern blazar that is detected from radio to very high-energy $\gamma$ rays. It has shown dramatic outbursts in the past, including in 1999 and 2009. The outbursts are in the X-ray band and are not accompanied by significant flux increases in other wavebands.

**What is new?**

We present new data of the source including quasi-simultaneous data during the 2009 outburst, as well as *NuSTAR* data during a period of quiescence

**Results**

In 2008–2009 ($\alpha$), the source was in a high-emission state with the X-ray flux reaching ∼20 times the flux of the quiet state. The 2009 flaring epoch is not as bright as the 1998 flare detected by *RXTE*, which reached an X-ray flux of nearly 50 times higher than the quiet state. In 2011-2012 ($\beta$) and 2020 ($\gamma$) it was in a quiet state. It is worth noting that both data sets are perfectly compatible in flux and spectral shape, i.e., the data suggest a stable period of quiescence at similar flux levels and physical conditions in the jet.

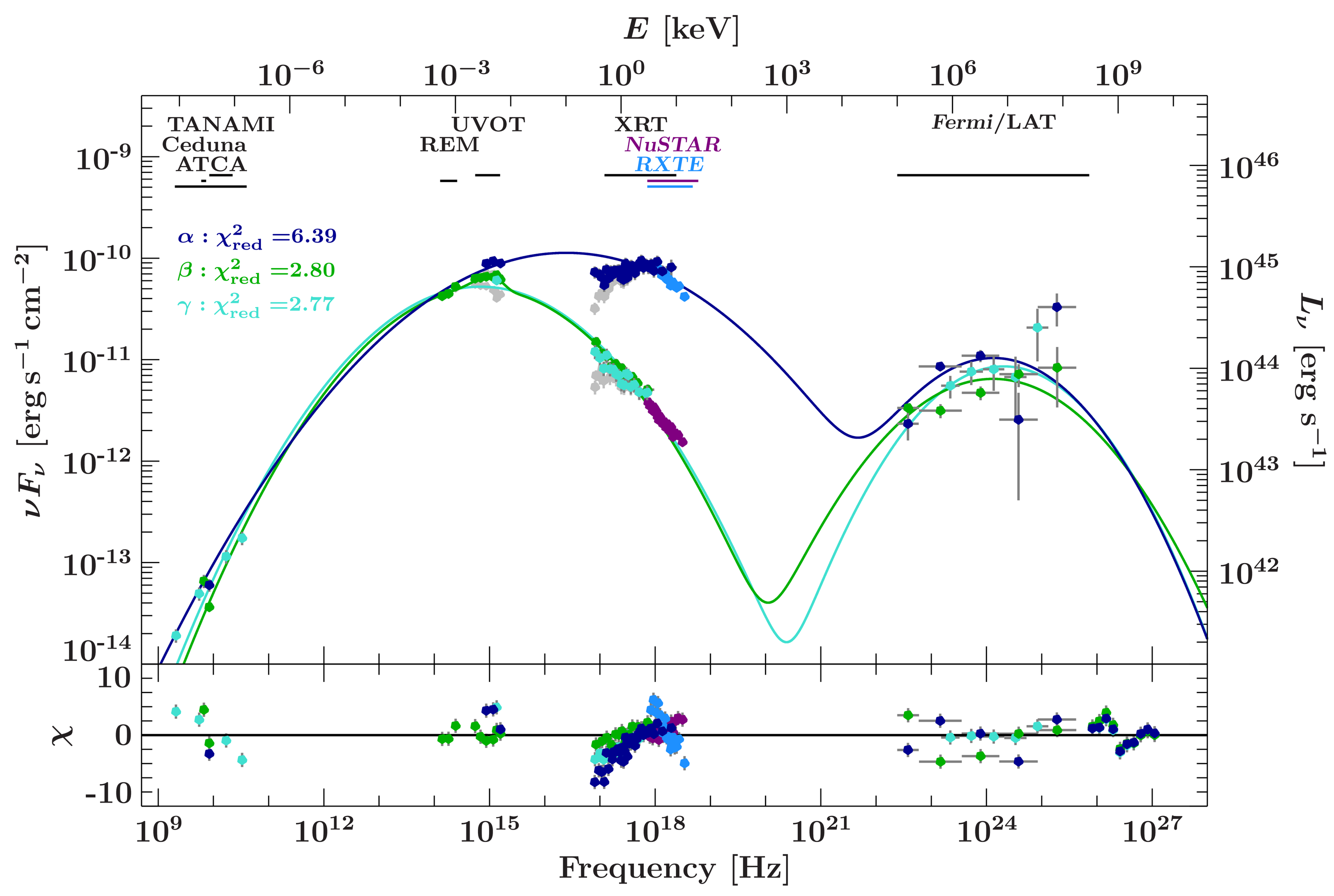


**Figure 1.** Quasi-simultaneous broadband SEDs of PKS 2005−489 during three different time ranges: $\alpha$ in 2009 (outburst, blue data), $\beta$ in 2012 (quiescence, green data), and $\gamma$ in 2020 (quiescence, turquoise and purple). The model is a simple logarithmic parabola. In a high flux state (blue), the source exhibits extreme X-ray flux variability that is not accompanied by flares in other wavebands (Chase O., McBride F. et al. submitted).

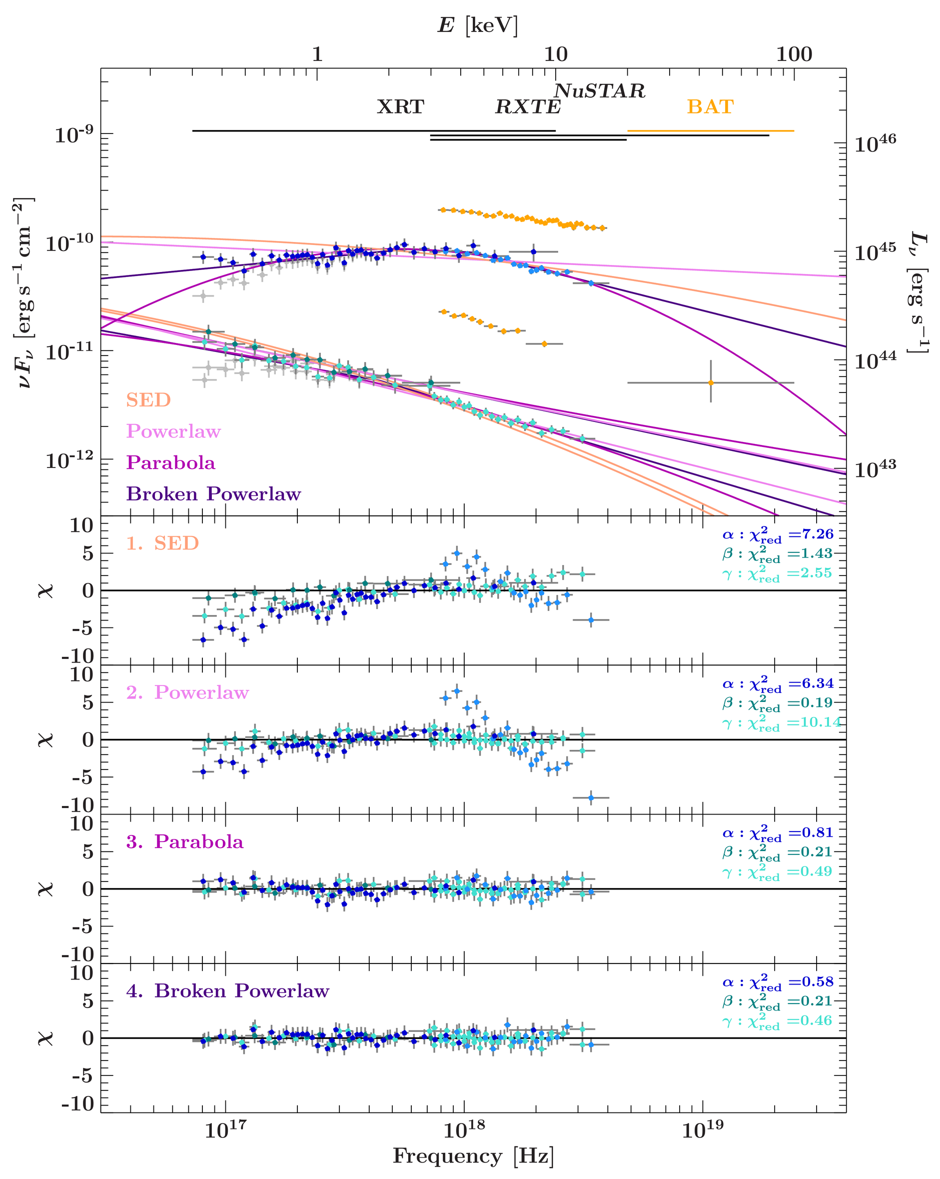


**Figure 2.** The X-ray spectrum of PKS 2005−489. We include simultaneous X-ray data and the absorbed data in gray. Four models are shown in orange, pink, magenta and purple in the top panel. Residual panels are shown below the plots and are shown in the color of each model. The 0.5–10 keV data (dark blue, green, and turquoise) are Swift/XRT data. Light blue data are RXTE/PCA data, while the turquoise data in the right panel include NuSTAR data (Chase O., McBride F. et al. submitted).

**Possible explanations of the peculiar X-ray feature in the high-flux state**

- ✗ **Instrumental feature:** *RXTE* data are consistent with *Swift*/XRT, indicating that an instrumental artifact or calibration issues can be ruled out. EXOSAT data presented in Giommi et al. (1990), show extreme flaring periods, strongly suggesting that this is not an instrumental issue.
- ✗ **Thermal feature:** A blackbody or disk model cannot adequately explain the data. Temperatures are higher than possible for a host galaxy or an accretion disk (Malkan 1983).
- ✗ **Hadronic origin:** In principle, the X-ray emission could result from synchrotron emission by secondary pairs generated by hadronic cascades (Böttcher et al., 2013; Keivani et al., 2018). This scenario requires extreme physical parameters (e.g. jet power) for the observed spectrum here. The proton cooling due to photomeson processes is slow, which is inconsistent with the fast X-ray variability that were previously observed in this source (Giommiet al., 1990; Sambruna et al.; 1995).
- ✓ **Jet emission component and magnetic reconnection** The X-ray spectrum may originate from synchrotron emission by high-energy nonthermal electrons in an environment with a high magnetic field. This can suppress the inverse Compton scattering, explaining the lack of $\gamma$-ray flaring. The X-ray flare may result from the emergence of a **new emission blob with very strong magnetic field**, not located in the emission region responsible for the low state. The high-energy electrons are probably accelerated via magnetic reconnection. Zhang et al. (2021) have shown that reconnection in a highly magnetized environment can lead to very hard X-ray synchrotron spectra. Both the flux and polarization can be strongly variable in reconnection, which may be examined by future X-ray polarimetry instruments.

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